same title on page 676, where on the other hand the main word of the title is omitted.

The Beiträge of von Staudt appeared in two parts, the first in 1856, the second in 1860. How could Whitehead have made the mistake of calling this second part a "3rd ed." ?

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PEARL AND JENNINGS ON ASSORTATIVE CONJUGATION IN THE PROTOZOA

IN general, the scientist's investigations receive the recognition they deserve from his fellow workers. This is true because the bulk of research consists in the working out of details in a scheme already stamped with authority. It is the unexpected, fundamentally new or truly brilliant result upon which the doctors disagree.

One of the best illustrations is a paper in *Biometrika* for February, 1907. In the demonstration of the existence of an assortative conjugation or homogamy in *Paramecium* analogous to the assortative mating previously found by Pearson in man, Pearl seemed to some of us to have struck a rich vein hitherto passed over by all prospectors. Others thought differently. Pearl's assays were discredited. In America, at least one review was declined. In England, J. J. Lister illustrated[1] by Pearl's paper his warning to biometricians to be sure they have a problem which is "sound from the standpoint of biology before bringing a formidable mathematical apparatus into action for its investigation."

Open criticism like that of Lister was more easily met[2] than the general indifference largely attributable to the *odium mathematicum*. This is now in a fair way to be overcome by the results being announced by Jennings. If these, in their turn, are being received by zoologists with but lukewarm enthusiasm, the fact indicates merely that the work is in advance of its time.

His recent study of conjugation in *Paramecium*[3] must be considered in comparison with Pearl's pioneer paper.[4]

a. Differentiation of Conjugants in Type and Variability.—The general belief that conjugants are on the average smaller than non-conjugants is quantitatively substantiated. In eleven "pure lines"[5] Jennings found conjugants to be from about 4 to nearly 14 per cent. smaller than the non-conjugants. In "wild" cultures, or in a mixture of differentiated pure lines, the mean for conjugants may be higher because only the large pure line is in conjugation. On the other hand, the conjugants may be abnormally small, 30 per cent. less than the non-conjugants, because only the smaller of the lines in the mixture is in conjugation.

Both absolutely and relatively, the conjugants are less variable than the non-conjugants. The difference in variability may be slight but generally it is large, for the conjugants are on an average about 33 per cent. less variable (relatively) than the non-conjugants.

The possible causes of this reduced variability are discussed. Lister's "Gametic Differentiation" is dismissed. Pearl's conclusion that equalization of individuals (undifferentiated or proconjugants) during the process of conjugation can not account for the lessened variability is confirmed. Jennings's conclusion, supported by abundant evidence, is that the low variability of conjugants is fully accounted for by the fact that conjugation does not occur till a certain growth stage has been reached, and does not occur in the largest individuals—the measurable variability of *Paramecium* being largely a growth phenomenon. Thus, the conjugants represent a definite and rather limited growth stage, the exclusion of both the larger and

[1] Lister, J. J., *Nature*, Vol. 74, pp. 584–585.

[2] Pearson, K., *Nature*, Vol. 74, pp. 465–466, 608–610, 635, 1907.

[3] Jennings, H. S., "Assortative Mating, Variability and Inheritance of Size in the Conjugation of *Paramecium*," *Journ. Exp. Zool.*, Vol. 11, pp. 1–134, July, 1911.

[4] Pearl, R., "A Biometrical Study of Conjugation in *Paramecium*," *Biometrika*, Vol. 5, pp. 213–297, 1907.

[5] The offspring of a single individual reproducing by fission has been called by Jennings a "pure line." In retaining the term here nothing more is implied than guaranteed purity of descent.

smaller individuals resulting in a pronounced reduction in variability. The growth factor may be in wild cultures supplemented by racial heterogeneity.

b. The Existence of an Assortative Mating.—Pearl's conclusion that there is a real assortative mating in *Paramecium* is backed up in every point by Jennings's more detailed study. Large individuals conjugate with large, small with small. Pearl's five series gave positive values of $r = .430$ to $r = .794$. Jennings's eight "wild" cultures of unknown racial composition all gave positive correlations of $r = .245$ to $r = .507$.

In twelve lots of conjugants from "pure races" with correlations ranging from $r = -.193$ to $r = .507$, there are ten positive and only two negative constants—both based on very small numbers and not statistically trustworthy with regard to their probable errors. The average of the twelve is $r = .251$. The correlation after separation of the pairs, is demonstrated to be greater than that determined on individuals which are united.

c. The Causes of the Assortative Mating.—Unquestionably, therefore, there is a real assortative conjugation. The redemonstration of the existence of a correlation between conjugants and the proof that it is not merely the result of heterogeneous cultures with only certain constituents in conjugation at one time is followed by a magnificent experimental-statistical analysis of the possible underlying factors. Equalization during mating, change of size during union, differential contraction due to killing fluid, environmental heterogeneity in the culture, are subjected to observation, experiment, measurement and statistical analysis. The specific results interest primarily the protozoologist. The broad and well-established conclusion is that the chief source of the correlation is, as Pearl five years ago maintained in *Biometrika*, a real assortative mating (larger individuals tending to conjugate with larger, smaller with smaller) arising in the fact that individuals must be of a certain degree of similarity in size to "fit."

d. The Evolutionary Significance of (a)–(c).—In connection with physiological differences resulting in different times of conjugation demonstrated by Jennings, the assortative conjugation is clearly a factor of the highest importance in the physiological isolation of the diverse races of *Paramecium*.

Apparently, the smaller size and lower variability of the conjugants have not a selective influence in maintaining the type of the population. The smaller extremes are, for the most part, younger than the conjugants, while the larger non-conjugants themselves conjugate after a few fissions. Moreover, the offspring of conjugants increase in size and in variability until they equal (or, in size exceed) the non-conjugants. Ex-conjugant offspring of individuals separated before completing conjugation.

Finally, the questions concerning the origin of heritable variations through conjugation within the "pure line," inextricably bound up as they are with the problem of the significance of conjugation, are reserved for a later paper. We are told, however, that heritable variations do, though rarely, arise as the result of conjugation within the "pure race."

Important as are the biological results of these two papers, their greatest value lies, not in concrete facts, but in their demonstration of the value of a widely applicable method. Let us hope they are only the beginning of the attack upon the many problems of morphology, physiology and genetics of the microorganisms which the biometric methods applied by Pearl and Jennings render possible.

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"THE PASSING OF THE SLIME-MOULDS"

ON the first page of a late number of SCIENCE, April 13, appears the heading of a brief note entitled "The Passing of the Slime-moulds," by Professor C. E. Bessey. One who reads no farther, having in mind such titles as "The Passing of the Buffalo," "The Passing of the Chinese Empire," etc., might possibly infer that the slime-moulds were doomed